



## Philosophical Transactions

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I. *Several Microscopical Observations on the Pumice-Stone, Coral, Spunges, &c. In a Letter from Mr Anthony Van Leuwenhoek, F. R. S.*

Delft, December 29, 1705.

I Have for some time made but few Observations; some of my Remarks made in the beginning of the Summer concerning the Pumice-stone, are as follows. I have several times heard say that that Stone which some People call *Dry*, others *Pumice-stone*, which I have seen the Silver-smiths use for scouring their Hammers, wherewith they beat out their Silver, and which is likewise used by Hatters in their Trade, that the said Pumice-stone is found driving in the Sea, and that the occasion of its lightness is, that it is calcined by the Fire before it is thrown out of the Burning Mountains, after such a manner as to fit it for swimming on the top of the Water.

I have oftentimes observed this Stone, but could never conceive that the Cavities which are found between the parts thereof (excepting those exceeding small Tubes or Pipes, some of which appear to be hollow) could be occasioned by Fire.

For if it were true, that such Stones were thrown out of the Volcano's, or Burning Mountains, very high into the Air, for instance, 200 Rods, according to all appearance, they would be red hot.

This being granted, let us suppose likewise that these glowing Stones will be four Seconds of a minute in rising to such a height, and four more seconds a falling into the Sea; in which time, according to our Hypothesis, it would

would be impossible for the Stones to be cold; from whence it would follow, that being all hot when they fell into the Sea, they must necessarily sink; for it is certain that the Heat cannot come into the cavities of the small Pipes without driving the Air out of them, now there being no Common Air in those Pipes while the Stones are glowing hot, and the said Stones falling immediately into the Sea, the Heat is expell'd by the Water, which insinuates itself presently into those Cavities, and consequently the Pumice-stone having its Pipes filled therewith, will sink down to the bottom, and not rise to the Superficies of the Water.

That this is so, we may be entirely satisfy'd if we take a piece of Wood-coal, that has been damp'd or extinguished, and throw it into the Water, we shall see how high it will rise, by reason of its lightness, above the Superficies thereof.

This piece of extinguished Coal being thrown into the Fire till it becomes red hot, all its Tubes or Pipes instead of Air are filled with a subtile Matter, which I shall call Fire; now if you throw that immediately into Water the Fire will be expelled from the Pipes, and since there can be no Vacuum, the Water will immediately succeed therein, and then that same piece of Wood-coal must necessarily sink to the bottom.

Now, that you may the better conceive the configuration of the so called *Dryf*, or Pumice-stone, I have placed several very small Particles thereof before a Microscope, which if they had been bigger, it would have been impossible to observe their shape.

Tab. 1. Fig. 1. A. B. C. D. E. F. G. H. represents a small Particle of the fore-mentioned Stone, in which you may perceive the very small Tubes, tho by reason of their exceeding smallness those Cavities can be seldom seen, some of the largest of them are described between G. and H. and  
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the most of those that are obvious to the Eye cannot however be easily delineated. I discovered moreover such exceeding fine Vessels, that several hundred of them are not equal to a single Hair in the Wool of Sheep.

The Stone is of a wonderful and inconceivable figure ; for as the Canals or Vessels in Trees and Plants do almost all of them appear very regular, running some Perpendicular, others Horizontally, the Canals of this Stone run so strangely, that one can hardly form any Idea thereof, especially when one views the Particles of it as they lye in those small Cavities or thereabouts.

The Cavities that are without these little Pipes in the Stone are of several sizes, and because these Particles of the Stone that were ranked near the Cavities appeared very wonderful to me, I caused the Painter to describe two of them as they stood before different Microscopes.

Fig. 2. I. K. L. M. N. O. P. Q. represents a small Particle of the said Stone, of which Q. I. K. L. M. N. lay near a Cavity that was in the Stone ; and wherein are described, as well as it is possible to do it, those small Pipes of which that part is composed.

Now as such a Stone is continually growing, or to speak more Philosophically, the Juices are always carried up through those Pipes, I suppose there happened some obstructions in bringing those Saps about L. M. by which means those little Branches that are described by N. O. and P. Q. shot them out into the Cavity of the Stone.

I placed before another Microscope a much smaller and thinner Particle of this Stone, as you may see in Fig. 3. S. T. U. W. X. Y. of which R. S. T. Y. lay near the Cavity that was in the Stone ; and as is before said, there happening some Obstructions in the Pipes or Vessels about S. T. U. by which the ascending Juices were forced to alter their Course, it occasioned an excrescence which bent or protruded itself into the Cavity of this Stone, as is described S. U. W. X. Y.

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After these Observations I talked with the Man that sells Colours, or the Materials for Dying, where this Stone is also to be bought; who told me that it was true that the Pumice-stone is found floating upon the Sea, but that there are no whole Rocks of those Stones, and that Sponges grow upon them.

Now, if what he affirmed is true, I imagin that some common Salt, otherways call'd Sea Salt, would be found in some of the Pores of this Stone; to satisfy my self therein, I took a piece of Stone about the bigness of the top of my Finger, and laid it upon some Wood-coal till it was glowing hot, and then threw it into clean Rain Water, imagining it would sink to the bottom; but I was deceived in my expectation, for most of the Water had insinuated itself into the Pores or Pipes of the Stone.

After this tryal I took the Particles of the Stone that was broke to pieces in the Water, and laid them upon a clean piece of Paper, and then put those pieces into Water again, in order to impregnate it with the Salt Particles that were in the Stone; then I placed some of the Water upon four distinct Glass Plates, and when it was almost evaporated I could perceive a great number of Salt Particles, whose Basis was an exact square; all the four sides of which ascended Pyramidically, the Superficies of others, which could be but just perceived by the help of a good Microscope, was a very small square, resembling the Coagulations of our Common Salt; and as our common Salt in moist Weather becomes liquid, so also did these; but so soon as it was fair and dry Weather again, the Watry Parts exhald, and the Salts resumed their former figure: I saw likewise amongst them some Particles that were Common Salt.

Now, I don't doubt but that many of these Pumice-stones are found in the Sea; for having viewed several of

them they did not appear to me to have any sharp Angles, and amongst the rest there was one of an Oval figure and as big a Man's Fist, and when it was thrown into the Water in my presence, I saw it float with the half of its Body above the Superfices of the Water ; from whence I concluded, that by its long driving in the Water the Angles of such a Stone were so worn off, that instead of having sharp and uneven points, they were grown to be blunt and smooth.

And it may also so happen, that from the Rocks, whether they be in the Sea or upon the Shoars thereof, such a soft Matter as these Stones seem to be composed of is torn or separated by stormy Winds.

When I laid the same Stone upon the Fire, I could perceive a smoaky Matter evaporating from it.

This last mentioned Experiment induced me to take some of the little pieces of the Stone, in order to keep together, as much as it was possible, the Matter which was exhaled from them ; and accordingly I did perceive that the first Matter which was driven off was as bright a Vapour as one should see, but the next, which was forced out by a yet stronger Fire, was nothing near so bright, and was moreover laden with an unspeakable number of exceeding small Particles ; which, by reason of their weight, sunk to the bottom, after which that Vapour became clear : There was also drawn off from the same Stone a little Matter, which I look upon to be Sulphur.

I have indeed before now heard say, that the Sponges which are found in the Sea did grow upon the Rocks, which however I could hardly conceive, believing that the solid Rocks could not produce such a sort of Matter ; but when I came to be informed that there are whole Rocks in the Sea composed of Pumice-stone, 'tis easy to imagine that they may produce such a Matter as we call Sponge.

I have formerly had one of these Spunges, in which I found a little hardnefs, and from that hardnefs I do suppose the Sponge received its first growth.

Having opened that part of the Sponge, I took out of it a little Shell and some very small Stones; the Shell was of a particular figure, and such as is not to be found upon the Strands of our Sea.

Thereupon I went to some of those Shops that sell Spunges, and examining the several Spunges, I took divers little Shells, Horns and Stones out of 'em, and amongst the rest one Shell that was bigger than any of those that I had seen before; from whence I concluded, that the storms, by putting the Sea into an extraordinary motion in or about those places where Spunges grow upon the Rocks, had raised from the Ground these little Shells and Stones and thrown them into the Spunges whilst they were growing; the rather because these little Shells and Stones were not only surrounded in such a manner by the Spunges as to impress their own figures in them, but even the parts of the Spunges had insinuated themselves into the little Shells, insomuch that they could not be separated from those Shells without breaking some of the parts of the Spunges.

Fig. 4. A. B. C. D. E. represents a little Shell or Scollope, which by the tearing it out of the Sponge was a little damaged, as you may perceive between C. and B; at A, there grew to it small parts of red Coral, and upon C and D there lay much smaller Particles of the same; there was some Coral too on that side of the Shell that was turned from the sight.

Between B and C we also discovered an Animalculum that is described like a Snake or an Eel; and I have observed the same, not only upon this Shell but also upon several little Stones that I have taken out of Spunges.

I had also a little piece of a Sea Shell, which we call a Horn, upon which, in 4 several places, there grew little Particles of red Coral.

This small piece of a Sea Horn was grown over with a petrified Matter, in which Matter there was a great many small Holes; and observing likewise several small long Animalcula that were also surrounded with a Petrified Matter, and whose Figures exactly agreed with those little Holes; I began to consider whether, or no these Animalcula might not have belonged formerly to those Sea Horns or Shells.

Fig. 5. F. G. H. Represents the said Particle of the Sea Horn, upon which there grew several small Particles of Coral between G and H.

I met likewise with 2 small pieces of an Ossified or Bony matter, which were hollow, and upon which likewise there grew a little Coral.

Now, That red Coral should grow in the bottom of the Sea is impossible to be conceived, or that the Coral matter, which is found upon the forementioned Shells and Stones, can be said to grow there, is what, with submission, we cannot allow of, but it ought rather to be called a Coagulation of such kind of Matters; and who knows but that all the white and red Coral that is found in the Sea is produc'd by such a Coagulation of Parts.

As for the Particles of the said Coral, they are not composed of Branches, but they lay by, and upon one another like the great Sands that were joyned to each other; but when one looks upon them through the Microscope, one can easily perceive that the parts of which they are composed were firmly united to each other, and that the Ground to which they were fixed was more broad than high.

I took this forementioned Scollop and Sea Horn, which was overspread with Coral, out of a great Sponge, but  
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tho I went into 2 other Shops that sold Spunges, and examined several of them, yet I could meet with no Shells that were covered with Coral.

Upon the abovementioned Observations, I consider'd with my self, whether the Pumice Stone was not to be found in the Mediterranean Sea.

Upon mentioning of Spunges, I cannot forbear telling you that I did not consider them a great many years ago, and was much astonish'd at the strange Production of them, because that in the growth of all Plants we may observe a sprouting out, which in the beginning thereof we call a Stem or Stalk, from which Stalk Boughs or Branches are produced, by which their parts become greater and more extended; but in the growth of Spunges it happens quite otherwise; for they have no Stem as far as it appears to us, nor growing thicker and larger; for their beginning and ending is much of the same magnitude, and out of one of their first Productions another like Particle sprouts out, and out of the second several others, but all of them very short.

To make you conceive the same, I have thought fit to describe a small Particle of Sponge as it appeared through a Microscope, as you may see in Fig. 6. I K L M N O P, which I pared off of a Sponge, as thin and as small as 'twas possible, where the parts of the Sponge are describ'd, coming one out of the other, and then united together again; and though we cannot conceive how the Sponge grows bigger, yet we may see that this is the manner of its encreasing.

For suppose that the parts broken off at K L or M N grow out so far that they come to touch one another and to joyn, new parts will grow out of them and unite themselves again, as we may see in the dissection of this small Particle of Sponge, which is altogether formed after this manner.

'Tis a common saying, That a Sponge will suck up a great deal of Water ; but I am not of that opinion, but rather conceive that the Water by the Pressure of the Air is forced up between the small concatenated parts of which the Sponge consists ; for if you put a dry Sponge into Water, some part of it will presently sink, that is to say, the Water will flow into the small Vacuities of those parts that are always linked together ; for supposing that the Water that is cover'd by the Sponge is not lyable to so great a Pressure of the Air as that Water that is open to it, (because the Air must lose a great deal of its weight before it can pass through the manifold Particles of the Sponge,) the parts of the Water lying round about the Sponge are consequently exposed to a greater Pressure, and by that means forced up into the parts of the Sponge where the Resistance is less.

Now that the Water which is most pressed should force up that that is least, is what we daily find by experience ; for if we cast our Eyes upon a Glass that is filled with Wine or Water, we shall always see that the Water will rise a little higher about the Edges than in the middle, because the Air that presses upon the Circumference of the Water, meets with greater Resistance than that which presses in the middle, as we have said before.

But if any one has a mind to be better convinced of the last Proposition, let him take a Glass Tube about the bigness of a Hens Quill or something slenderer, and only put it into Water, and he will find that the Water in the Tube will rise higher than the Surface of the Water without ; the reason of which is, that the Pressure of the Air upon the Water that is within the Tube, is not so strong as the Pressure upon the Water without.

For my farther satisfaction concerning Sponges, I took a small piece of Sponge, and with my Scizzars cut it into 2 pieces, and put one of the pieces into Water, and after

a small space of Time (sufficient for it to subside to the bottom) I viewed both the dry piece and the wet with a Microscope, and how nicely soever I observed them, I could not discover that the parts of the one were thicker than the parts of the other.

Moreover, I viewed again the parts of the Sponge as exactly as it was possible for me to do it, but I could never discover that there was the least Concavity in the slender parts thereof, for if there were any Concavity in them, I conceive it would appear when I examined those fine parts with my Microscope: For my farther satisfaction, I prepared a Glass Tube that was slenderer than one of the Particles of the Sponge, and was withal hallow, and I placed the same before a Microscope, having put a small Drop of Water into one end of it, and then I viewed it again, at which time it appeared clearly to me (as I have seen several times before) how far the Water was come into the Tube, for where the Water is, there the Glass appears as a solid Body; whereas on the contrary, in a Glass that is hallow, the Concavity alone is only Transparent, but the sides do not appear so Transparent.

After this I endeavoured to divide the exceeding slender parts of the Sponge lengthways, because I do conclude that slender parts have no strength unless they are compos'd of yet slenderer parts, which was very difficult for me to do, because they are so strictly united to each other; however I was sufficiently convinced that the said slender parts do consist of yet much finer.

Tab: 1

Fig: 3

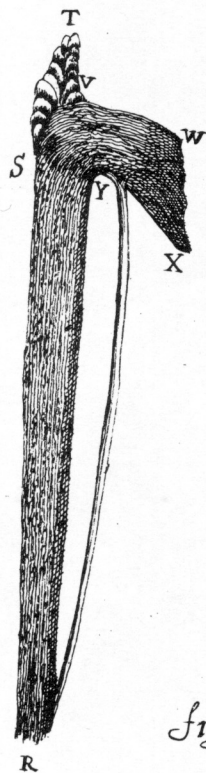


Fig: 2

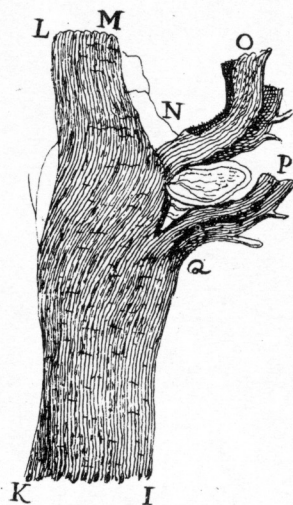


Fig: 1

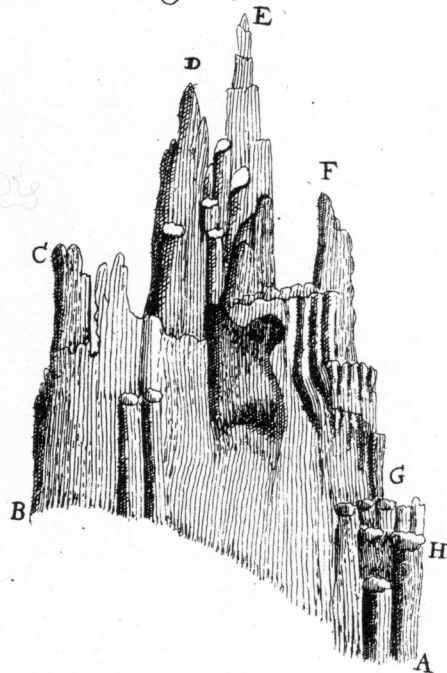


Fig: 6

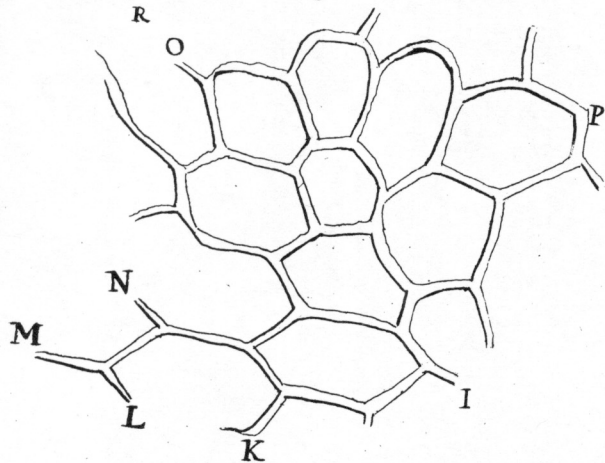


Fig: 5



Fig: 4

